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Development and evaluation of vitamin A and vitamin C enriched fruit roll

M Navyath Reddy[1], D Kodanda Ram Reddy[2*]
[1]Society for Energy, Environment and Development, Jubliee Hills, Hyderabad, Telangana, India
[2] Department of Food Technology, Osmania University, Hyderabad, Telangana, India

Abstract
The fruit rolls are made of carrot and guava pulp to make Vitamin C and Vitamin A enriched rolls and to meet the 20% of RDA of Vitamin C and Vitamin A for 25g of product intake and extensive trials were done to find out the best combination by using blending technology and finally, the ratio of 60:40 of guava and carrot pulp was mixed with other ingredients. The mixture was then dried in a solar dryer patented by Society for Energy, Environment and Development for about 12-16 hours at a range of 50-60°C. The dried mixture was cut, made into rolls, packed, and kept for storage at three different conditions and analyzed physico-chemical, nutritional, overall acceptability, and microbial parameters. It was concluded that the shelf-life of enriched leather is about 3 months with the objective of 20% of RDA of Vitamin C and Vitamin A for 25g of product intake.

Keywords: solar dehydration, mixed fruit roll, storage studies, overall acceptability, RDA

Introduction

Fruits and vegetables are an excellent source of energy, minerals, vitamins, bioactive compounds (Phenols, carotenoids), and fiber. Fruits and vegetables are an important nutritional requirement of human beings as these foods not only meet the quantitative needs to some extent but also supply vitamins and minerals which improve the quality of the diet and maintain health. Fresh fruits are more liable to deteriorate under tropical conditions due to high temperature, humidity, pests, and disease infestation. Today, foods are not only intended to satisfy hunger and provide necessary nutrients for humans but also to prevent nutrition-related diseases. There is a good possibility of enhancing the flavor and acceptability by using blending technology. Fruit Leathers also knows as fruit bars, fruit rolls or fruit slabs is a dehydrated fruit pulp based confectionary mixed with other ingredients such as sugar, pectin, and citric acid where often eaten as snack or dessert. Fruit leathers are rich in fiber, carbohydrates, and low in fat as most of them contain fruit pulp and sugar. Fruit leathers made by blending with two or more fruits will have better nutritional qualities. Dehydration of fruits and vegetables is one of the preservation technique where, Conventional air-drying is cost and energy-intensive, because, it is a simultaneous heat and mass transfer process accompanied by phase change. Where solar drying is a modification of traditional sun drying and it is one cost-effective preservation of drying for agricultural commodities. The solar dryer used in this project has the major innovation of forced circulation of hot air using fans run by electricity generated by photovoltaic cells which, completely avoids conventional electricity which was patented by SEED (Society for Energy, Environment, and Development).

Guava (*Psidium guajava* L.) is a tropical fruit with a sweet aroma and pleasant sour & sweet taste having high nutritive and medicinal values. It is also known as ‘Poor man’s apple of tropics’. Commercially, the fruit is consumed as raw or used in making jams, jellies, pastes, juice, and powders. The guava is also rich in antioxidants, phytochemicals, flavonoids and a rich source of vitamin C contains about 80 to 200 mg per 100g and contains a fair amount of minerals. The minerals present in the guava mainly are potassium, phosphorus, calcium, and magnesium. Whereas, Carrot (Daucus carota L.) is a rich source of β-carotene and contains other vitamins, like thiamine, riboflavin, vitamin B-complex and minerals and also known for its health benefits like Antioxidant, Anticarcinogen, Anti-diabetic, Cholesterol and Cardiovascular disease lowering ability.

This study aims to standardize the ratio of pulp and to study the storage- studies for vitamin and vitamin C enriched fruit roll until the RDA of 20% retained.

Materials and Methods

1. Materials

Guava and carrot were procured from the local market. After washing, cut into pieces, blanched, and made into pulp. Sugar, maltodextrin, liquid glucose, citric acid, and pectin were used in the preparation of fruit roll were procured from the local market of Hyderabad, Telangana.

2. Methods

Initially, trials were made to find out the best combination with guava, papaya, and carrot with different combinations but 60% Guava + 40% Carrot was found superior and further research has been carried out. The pulp was mixed according to the percentage and based on the weight of pulp sugar (23%), Maltodextrin (5%), Liquid glucose (5%), Citric acid (0.2%), and Water (5.3%) were mixed on heated on low flame until sugar dissolves then pectin (1.5%) was added to the hot syrup and mixed. The hot syrup then added to the mixed pulp and cooled. At last, the KMS (0.02%) was added then the mixture was spread on a food-grade stainless steel tray kept in a solar dryer for 6-8hrs and then 2nd layer was poured and then continued for another 8hrs. Dried sheets were cut into rectangular shapes and rolled, packed in polypropylene boxes, and then shrink-wrapped and analyzed for Physicochemical, Nutritional and Sensory parameters during shelf-life when kept at room temperature (25 ± 1^{0}C), Freezer (-20^{0}C), and Environmental chamber (40^{0}C at 85% RH) for 30 days and analyzed every 7 days.

Flow Chart of Preparation of Vitamin A and Vitamin C Enriched leather

The method used for the preparation of is **Vitamin A and Vitamin C enriched leather** solar dehydration technique.

Procurement of fruits from local markets

↓

Fruits were washed using clean tap water

↓

Fruits were blanched with hot water for 2-3 minutes (90ºC)

↓

Fruits were passed through the pulp extractor

↓

Pulp was collected in a vessel

↓

Pulp was blended with syrup

↓

The mixture was poured into stainless steel trays and dried in a solar cabinet dryer

↓

After drying mixture was cut down into slabs and were given the shape of rolls

↓

Rolls were packed in plastic boxes and shrink wrapping was done to containers

Analytical Procedures

Moisture content, titrable acidity, reducing sugars total sugars, vitamin C, browning index and β carotene was estimated as described by Ranganna (1994). Sensory quality was assessed by using a hedonic scale using semi trained panels as described by Ranganna (1994). The statistical analysis of storage studies was carried out by ANOVA by using Instat graph pad software by Tukey – Kramer multiple comparison test for three replications.

Results and Discussion

The analyzed Physico-chemical parameters of Carrot pulp, Guava pulp, and Guava – Carrot rolls were given in Table 1.

Table 1: Physico-chemical parameters of Guava, Carrot pulp, and Guava – Carrot Rolls

Parameters	Carrot pulp	Guava pulp	Guava–Carrot rolls
Moisture (%)	87.390±0.178	86.380±0.13	11.967±0.004
Titrable Acidity (%)	0.072±0.02	0.330±0.01	0.810±0.002
pH	5.77±0.01	3.96±0.01	3.63±0.11
TSS (°Brix)	5.03±0.05	7.0±0.1	74.52±0.34
Reducing Sugars (%)	5.44±0.17	1.68±0.034	17.55±0.07
Total Sugars (%)	7.98±0.14	5.42±0.06	41.403±0.22
β Carotene (mg/100g)	5.186±0.07	0.759±0.03	4.766±0.06
Vitamin C (mg/100g)	5.043±3.20	179.043±4.85	82.16±1.94
Browning Index	----------	----------	0.049±0.004
Note: *Each value is mean of three determinations ± Standard Deviation value			

Moisture (%)
The moisture content was found decreased in freezing and ambient for 4 weeks during storage from initial 11.967±0.004 to 11.748±0.079 and 10.987±0.018 respectively. Whereas found increased trend in accelerated storage conditions. The decrease in moisture may be due to migration of moisture might be due to migration of moisture to surroundings through packing material and increase might be due to absorption of moisture from surrounding due to increase in temperature and humidity for accelerated conditions were reported by Laxman Kumar *et al.*, for papaya – guava fruit bar and Jaydeep Singh *et al.*, for guava-carrot jelly. Fig 1 shows moisture content for three different types of storages. Table 1 & 2 shows Physico-chemical and Nutritional values for three different types of storages.

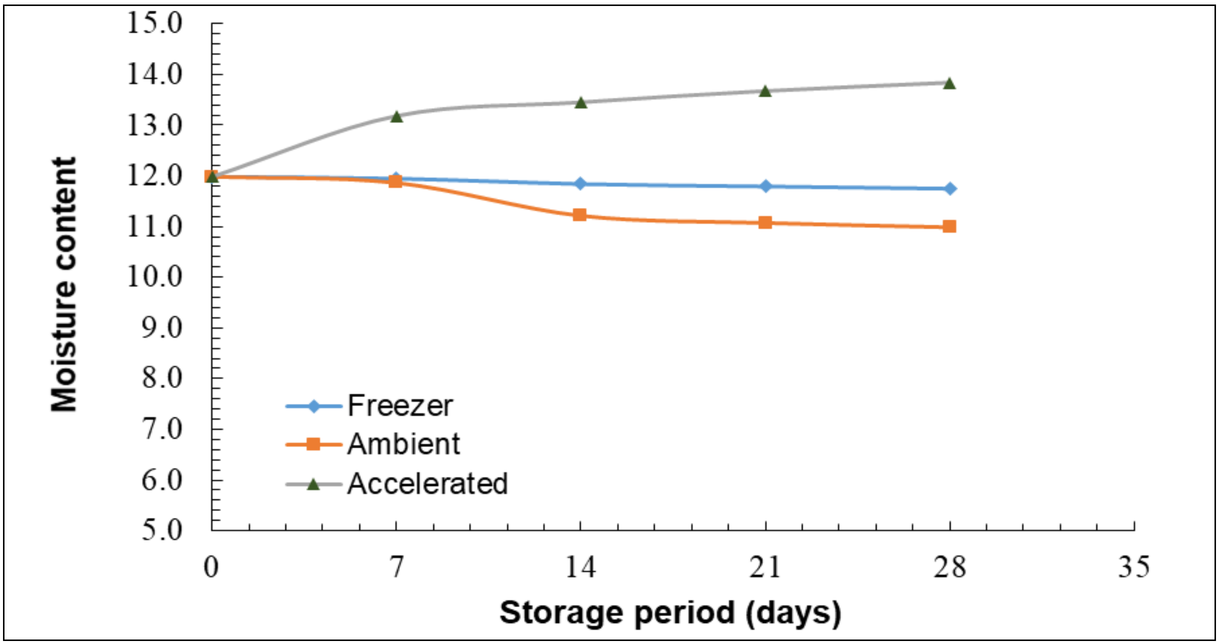

Fig 1: shows moisture content for three different types of storages

pH Content
The pH value decreased in all the storage periods during the storage days. The decrease in pH is might be due to conversion pectin or liquid glucose which may further converted into acids during storage. The decrease in pH content was reported by Saranya *et al.*, for papaya fruit rolls, Sher Hassan *et al.*, for guava apple blended fruit leather.

Titrable Acidity (%)
The acidity was increased from the 0th day to the last day of the storage period. The increase in acidity in all different storage periods as an advancement of storage it might due to the formation of acids from sugars or degradation of ascorbic acid or conversion of sulphur dioxide to sulphrous acid during storage. Fig 4.3 shows Titrable acidity (%) with storage periods.

Reducing sugars (%)
Reducing sugars was increased in all different types of storages as an advancement of storage to 18.670±0.21 for freezing, 18.788±0.34 for ambient, and 19.761±0.23 for the accelerated type of storage. The increase in the reducing sugars % might be due to inversion of sugars or conversion of complex sugars into simple sugars due to an increase in acidity and temperature. The findings are reported by Ullah *et al.*, for carrot, apple blended jam, Anisa *et al.*, for honey-based carrot candy, and Patil *et al.*, for guava jam blended with sapota.

Table 2: Physico-chemical values for different parameters for three different types of storages

S. No	Parameters	Storage condition	Storage days (weeks)				
			0th week	1st week	2nd week	3rd week	4th week
1	Moisture	Freezer	11.967±0.00a	11.948±0.06 b	11.840±0.09 b	11.792±0.03 a	11.748±0.07 a
		Ambient		11.863±0.10 b	11.214±0.20 a	11.073±0.04 a	10.987±0.01 a
		Accelerated		13.184±0.14 a	13.454±0.26 a	13.676±0.03 a	13.841±0.00 a
2	pH	Freezer	3.63±0.01a	3.63±0.01 b	3.62±0.01 b	3.61±0.00 a	3.60±0.01 a
		Ambient		3.63±0.00 b	3.61±0.00 b	3.59±0.01 a	3.57±0.01 a
		Accelerated		3.61±0.01 b	3.58±0.00 a	3.56±0.00 a	3.53±0.03 a
3	Titrable Acidity (%)	Freezer	0.810±0.00a	0.816±0.00 b	0.825±0.00 c	0.827±0.0 d	0.831±0.02 e
		Ambient		0.865±0.00 a	0.879±0.01 a	0.881±0.01 a	0.892±0.02 a
		Accelerated		0.917±0.00 a	0.946±0.01 a	0.953±0.01 a	0.970±0.00 a
4	Reducing Sugars (%)	Freezer	17.55±0.34 a	17.72±0.20 b	18.163±0.11a	18.47±0.13 a	18.64±0.21 a
		Ambient		18.24±0.13 a	18.35±0.04 a	18.45±0.10 a	18.78±0.34 a
		Accelerated		18.51±0.08 a	19.08±0.02 a	19.51±0.02 a	19.76±0.23 a
5	Total Sugars (%)	Freezer	41.40±0.22 a	41.26±0.12 b	40.55±0.33 a	40.33±0.13 a	40.23±0.10 a
		Ambient		41.30±0.33 b	41.01±0.17 c	39.50±0.16 a	39.04±0.41 a
		Accelerated		40.56±0.15 a	38.78±0.11 a	38.03±0.16 a	37.29±0.12 a

Note: *Each value is mean of three determinations ± Standard Deviation value The same letter in superscript represents the values are significant (p≤0.05)

Total sugars (%)
Total sugars are found in a decreasing trend irrespective of the storage condition as the storage period increases. The decrease in total sugars irrespective of storage conditions might be due to the conversion complex into simple sugars or due to participation in browning reactions. These findings were reported by Piyush *et al.*, for papaya banana mixed fruit bar and Bhalerao *et al.*, for mango – papaya fruit bar.

β Carotene content (mg/100g)
β Carotene content found to be in decreasing trend with irrespective of storage conditions from initial week 4.766±0.06 to 4.698±0.01 in the freezer, 4.377±0.05 in ambient and 3.918±0.10 in accelerated storage conditions as storage period increases. Fig 4 shows the β Carotene (mg/100g) values for different types of storage during storage periods, the decrease in carotene content as the advancement of storage may be due to degradation of β Carotene and due to increase in acidity. This was reported by Saket Mishra *et al.*, for protein and beta carotene-rich guava fruit bar.

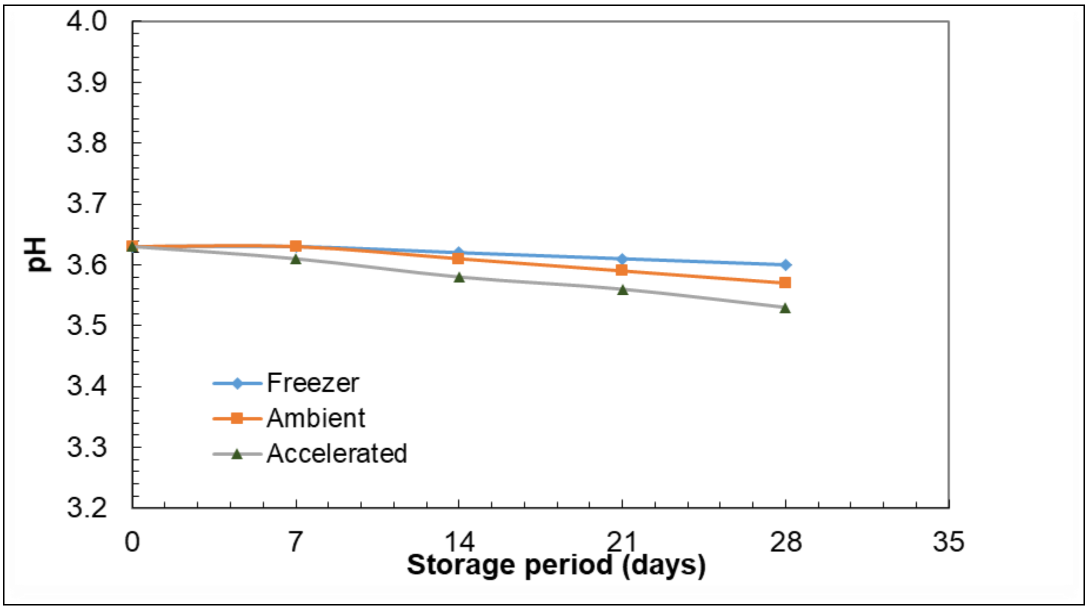

Fig 2: pH values for different storage conditions for storage days

Table 3: Nutritional Parameters values for three different types of storage

S. No	Parameters	Storage condition	Storage days (weeks)				
			0th week	1st week	2nd week	3rd week	4th week
1	β Carotene (mg/100g)	Freezer	4.76±0.06 a	4.75±0.03 b	4.71±0.02 c	4.70±0.02 d	4.69±0.01 e
		Ambient		4.72±0.03 b	4.58±0.04 a	4.56±0.05 a	4.37±0.05 a

		Accelerated		4.55±0.01 [a]	4.22±0.01 [a]	4.14±0.01 [a]	3.98±0.10 [a]
2	Vitamin C (mg/100g)	Freezer	82.16±1.9 [a]	78.29±0.14 [a]	72.70±1.8 [a]	69.89±0.06 [a]	63.09±1.74 [a]
		Ambient		71.06±0.45 [a]	65.88±0.66 [a]	57.50±1.83 [a]	47.07±1.79 [a]
		Accelerated		63.58±0.15 [a]	49.32±0.12 [a]	38.61±1.76 [a]	19.18±0.13 [a]
3	Browning Index	Freezer	0.049±0.004[a]	0.066±0.00 [a]	0.071±0.001[a]	0.077±0.002[a]	0.079±0.002 [a]
		Ambient		0.069±0.002[a]	0.076±0.002[a]	0.079±0.005[a]	0.084±0.001 [a]
		Accelerated		0.089±0.004[a]	0.148±0.003[a]	0.222±0.001[a]	0.226±0.002 [a]
4	Overall Acceptability	Freezer	8.4±0.19 [a]	8.4±0.189 [b]	8.2±0.405 [c]	8.0±0.343 [d]	7.7±0.446 [e]
		Ambient		8.1±0.283 [b]	7.7±0.343 [c]	7.3±0.474 [a]	7.0±0.486 [a]
		Accelerated		7.9±0.510 [b]	7.3±0.523 [c]	6.6±0.480 [a]	6.0±0.655 [a]

Note: *Each value is mean of three determinations ± Standard Deviation value The same letter in superscript represents the values are significant (p≤0.05)

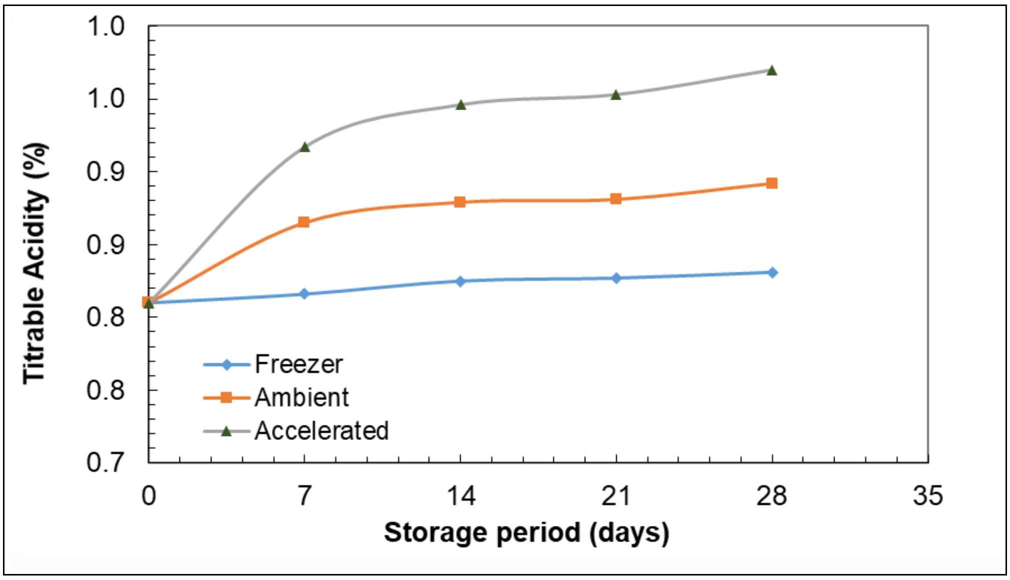

Fig 3: Titrable acidity values of different storage conditions to storage days

Vitamin C (mg/100g)

Vitamin C decreased as advancement in shelf-life irrespective of storage conditions the maximum decrease was found in accelerated storage followed by ambient and freezing. The decreased values were found to be significant in freezing and found highly significant in ambient and accelerated. The decrease may be due to oxidation of ascorbic acid to dehydroascorbic acid followed by hydrolysis latter to 2,3-diketogluconic acid. Fig 5 shows the vitamin C content (mg/100g) values for different types of storage during storage periods. The decrease in vitamin C was reported by Piyush *et al.*, for papaya banana mixed fruit bar, Rajani Singh *et al.*, for guava – papaya mixed fruit leather, and Chavan *et al.*, for guava leather.

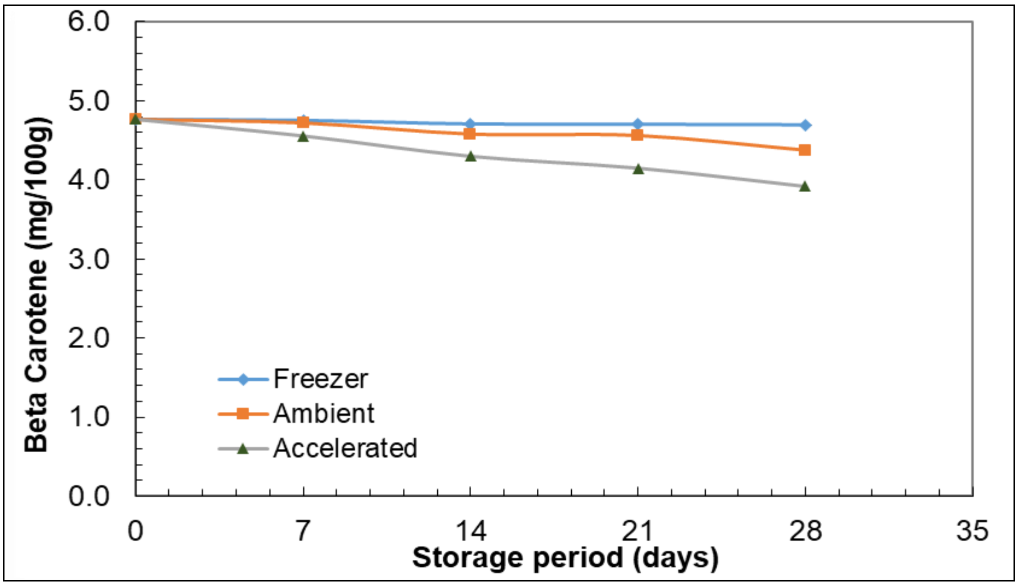

Fig 4: β: Carotene (mg/100g) values for different types of storages during storage periods

Browning Index

The browning index increased for all types of storage conditions as shelf-life prolonged. The maximum value found in accelerated condition 0.226±0.002 followed by ambient 0.084±0.001 and freezing 0.079±0.002 for the last week of storage and values found to be highly significant in all the cases. The increase in the browning index may be of non-enzymatic browning due to the presence of sugars. These findings were reported by Jayadeep *et al.*, for guava- carrot candy.

Microbial parameters

The fruit bar was analyzed for both total plate count and yeast and mold count during the storage there was a slight increase in microbial content during storage where the maximum was found in accelerated storage condition at the 4th week of storage was about $4x10^4$ CFU/g and the minimum was found in freezing storage was about $3x10^2$ CFU/g at 4th week of storage and the values were found to be below the standards for total plate count and there was no yeast and mold growth during the shelf-life study in any of those storage conditions. Table 3.3 shows the microbial analysis of fruit leather for different storage conditions on the advancement of storage.

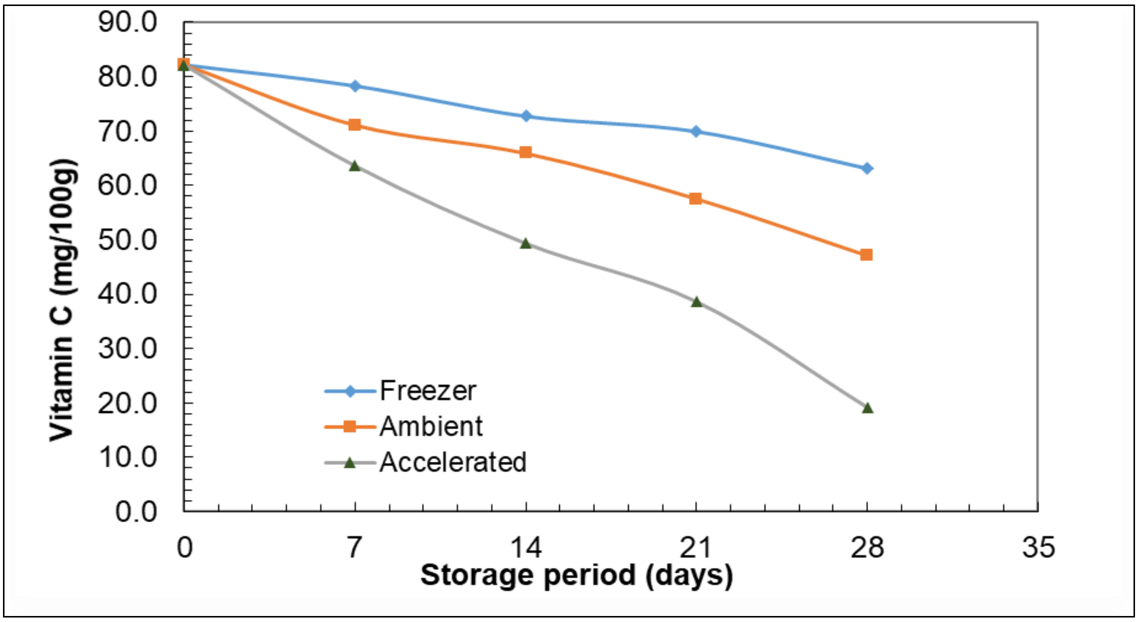

Fig 5: Vitamin C (mg/100g) values for different types of storage during storage periods.

Table 4: Microbial analysis of different storage conditions during the storage period.

Storage Condition	Storage Period (Weeks)					
	Dilution	**0th week**	**1st week**	**2nd week**	**3rd week**	**4th week**
Freezer	10^{-2}		Nil	$1x10^2$ CFU/g	$1x10^2$ CFU/g	$3x10^2$ CFU/g
	10^{-3}		Nil	Nil	Nil	Nil
	10^{-4}		Nil	Nil	Nil	Nil
Ambient	10^{-2}		$4x10^2$ CFU/g	$7x10^2$ CFU/g	$8x10^2$ CFU/g	$8x10^2$ CFU/g
	10^{-3}	0	Nil	$1x10^3$ CFU/g	$1x10^3$ CFU/g	$1x10^3$ CFU/g
	10^{-4}		Nil	Nil	$1x10^4$ CFU/g	$4x10^4$ CFU/g
Accelerated	10^{-2}		$5x10^2$ CFU/g	$6x10^2$ CFU/g	$8x10^2$ CFU/g	$9x10^2$ CFU/g
	10^{-3}		$2x10^3$ CFU/g	$2x10^3$ CFU/g	$3x10^3$ CFU/g	$3x10^3$ CFU/g
	10^{-4}		Nil	$1x10^4$ CFU/g	$1x10^4$ CFU/g	$3x10^4$ CFU/g

Conclusions

1. The Physico-chemical parameters found good in all the three type of storages whereas the increase in moisture was seen in accelerated storage condition and found to decrease in both freezer and ambient storage conditions due to temperature difference. TSS found decreased in accelerated whereas found to have inverse effect on other storage conditions. However, other parameters like pH, acidity, total sugars and browning index found in increasing trend as advancement in storage period.
2. The nutritional parameters were found good but found to be decreasing as advancement in shelf-life whereas the RDA of 20% was not found at accelerated storage condition at the 4th week of storage so this is the reason that shelf-life studies were not studied further.
3. The overall acceptability was found great at the initial stage and found to have a little effect during storage studies. But, found to be acceptable.

4. The product found to be microbial stable as they found to be confirming with the standards in all the storage conditions and concluded to have 3 months of shelf-life.

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